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Research Article

Dispersal rate of *Potamophylax cingulatus* and *Micropterna sequax* (Trichoptera) in Iceland*

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Abstract

During the 20th and 21st century, two species of Trichoptera have colonised Iceland. One species is *Potamophylax cingulatus* and the other is *Micropterna sequax*.

Potamophylax cingulatus was not found in several extensive surveys before 1942, conducted by several entomologists. During a survey in streams in 1974–1978, the species was found to be common in east and north-east Iceland, but the Trichoptera species *Apatania zonella* was absent, where it was common before 1942. Searching collections of unidentified Trichoptera, a single specimen was found in east Iceland on 30 July 1959. The survey was repeated in 2004–2006 and the species had colonised most streams and rivers in Iceland and *A. zonella* had disappeared from many of them. *Potamophylax cingulatus* was first recorded in two light traps in south Iceland in 1997 with two specimens. The catch has increased continuously to 267 in 2022.

Micropterna sequax was found in a single light trap at Mógilsá near Reykjavik in 2008. The annual catch has since grown from two specimens to 144. The species was found at Hvanneyri, 40 km north of the original site it was recorded from in 2018 (8 specimens) and, in 2021, it was found in Kjós, 11 km from the original site (one specimen based on a photograph).

The dispersal rate for *P. cingulatus* was about 7–9 km/year, but the dispersal rate for the more recent settler *M. sequax* was found to be 4 km/year.

Key Words

Colonisation, dispersal, population growth, Trichoptera

Introduction

During the last Ice Age, all of Iceland was covered with ice. The coldest period was 25 k years ago, when the extent of the ice cover in Iceland was up to 100 nautical miles off the present coastline (Geirsdóttir et al. 2009, 2013), indicating no ice-free areas on the island. The Ice Age ended abruptly 11 k years ago, when the temperature rose from severe coldness in the North Atlantic islands to a climate warmer than today in a few decades (Dansgaard et al. 1993; Geirsdóttir et al. 2013). No terrestrial or freshwater life could have survived this condition, except for two subterraneous groundwater amphipod species (Kristjánsson and Svavarsson 2007). The present Trichoptera fauna is therefore post-glacial.

The first comprehensive survey on insects in Iceland was made in the late 1920s, where new and older insect records were published (Lindroth 1931). Ten species of Trichoptera were recorded. Only one additional study was made when Trichoptera were collected (Anderson and Falk 1935) with no additional species recorded. Therefore, when Fristup (1942) published his annotated checklist of Trichoptera of Iceland, 10 species were known.

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Both *Potamophylax cingulatus* and *Micropterna sequax* occupy running waters as larvae, *P. cingulatus* in most kind of running waters in Iceland (Gíslason 1981a) and *M. sequax* more in intermitted streams in Europe (Hickin 1967; Otto 1974; Hoppeler et al. 2018). Larvae of *M. sequax* have not yet been found in Iceland. Both species are mainly detritus feeders (Otto 1974; Vestveer 2018).

In the 1930s *Apatania zonella* was the dominating stream-dwelling Trichoptera. During an extensive collection of Trichoptera in streams in 1974–1978 (Gíslason 1981a, b), one new species, namely *P. cingulatus*, was recorded (Gíslason 1974). *Potamophylax cingulatus* was common in running waters in eastern and north-eastern parts of Iceland, but *A. zonella* was almost absent from streams where it was common in earlier surveys and now occupied with *P. cingulatus*. Gíslason (1981b) showed that *P. cingulatus* eliminated *A. zonella* from these streams by predation. Searching earlier collections of unidentified Trichoptera, a single specimen had been found in east Iceland on 30 July 1959. The survey was repeated in 2004–2006 and the species was found to have colonised most streams and rivers in Iceland and *A. zonella* had disappeared from many of them. A second record of a new Trichoptera was when *M. sequax* (incorrectly identified as *Micropterna lateralis*) was discovered near Reykjavik in 2008 (Ólafsson and Gíslason 2010). That species has now dispersed 40 km from the original site.

The main objective of this study was to estimate the dispersal and exponential rate of the two recent Trichoptera species that have colonised Iceland. This was achieved by following their population growth from the time they were first recorded and, thereby, gives us a good picture of their establishment in each area.

Material and methods

Distribution records are based on published material (Gíslason 1981a, b; Gíslason et al. 2015; Pálsson et al. 2016), two light traps at Tumastadir in Fljótshlid, south Iceland (64°44'22"N, 20°3'52"W) operated from 1995, a single light trap operated at Mógilsá (64°12'59"N, 21°42'48"W) near Reykjavik from 2005 and at Hvanneyri (64°33'43"N, 21°46'14"W) from 2010 (Swedish Ryrholm type). Their light sources were Standard High Pressure Mercury lamps (Philips HPL-N 125W e27). These traps were operated each year for 30 weeks from April to November. The light traps are part of the more extensive Lepidoptera survey conducted by the Icelandic Institute of Natural History, but several other orders of insects have been collected and identified (Ólafsson and Björnsson 1997).

Results

From 1974 to 1978, a comprehensive study was made on the distribution of Trichoptera in Iceland (Gíslason 1981a). In this survey, *P. cingulatus* was distributed in the east and north-east of Iceland, but absent from other parts (Fig. 1) (Gíslason 1981a, b). A survey was made in 2005–2006 and the same streams were sampled (Gíslason et al. 2015). At that time, *P. cingulatus* was found in all parts of Iceland.

The first *P. cingulatus* was recorded in light traps at Tumastadir, south Iceland, in 1997, two years after its first operation (Fig. 2). Only two specimens were caught in 1997, but 267 in 2022.

By measuring the shortest distance from the 1974–1978 distribution to the areas it was found in later

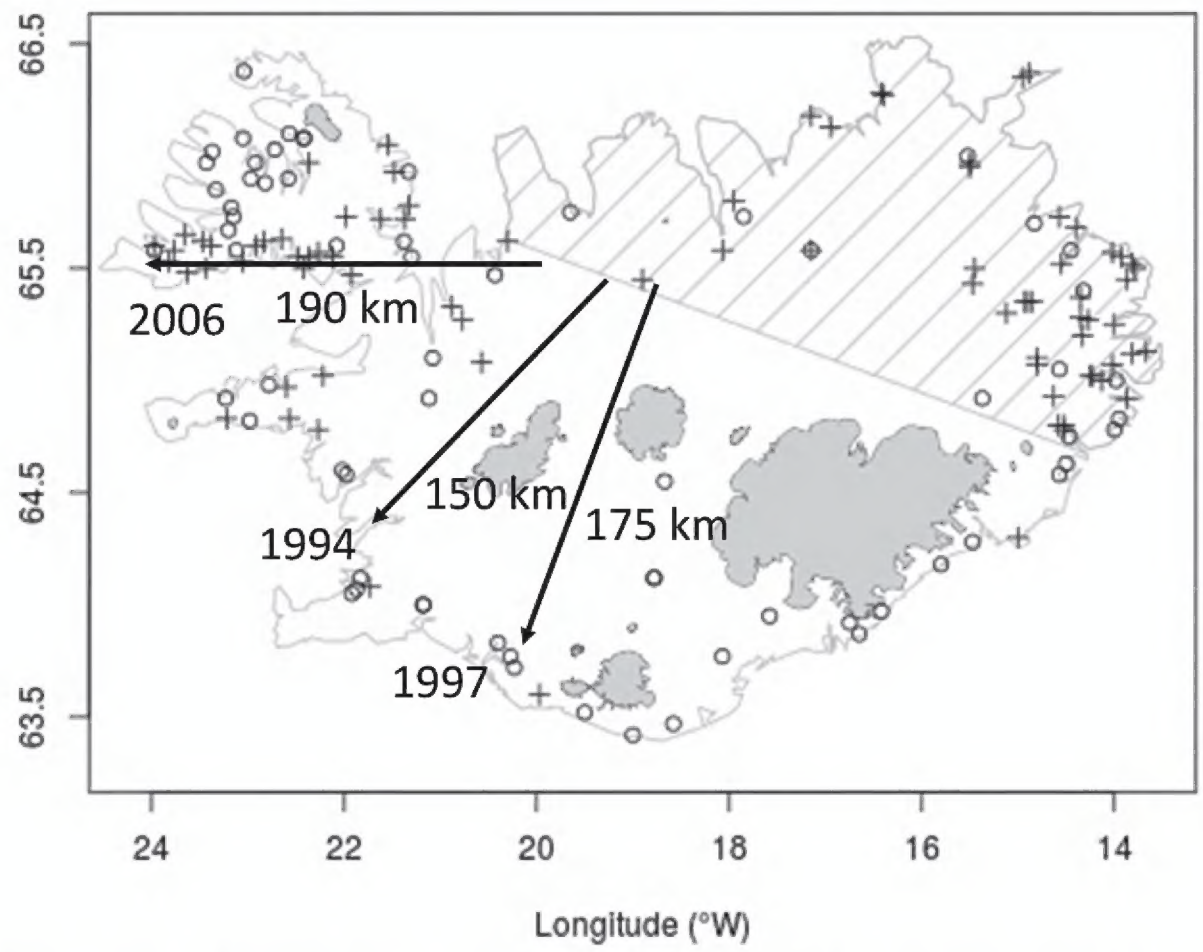

Figure 1. Distribution of *Potamophylax cingulatus*. Distribution in 1974–1978 (shaded). More recent records (+) and survey sites where the species was not recorded (o). Glaciers shown in grey. Shortest distance shown from the 1974–1978 distribution to the sites of first record in the 2005–2006 studies. Dispersal rate are 190 km/28 years = 7 km/year, 150 km/16 years = 9 km/year and 175 km/19 years = 9 km/year.

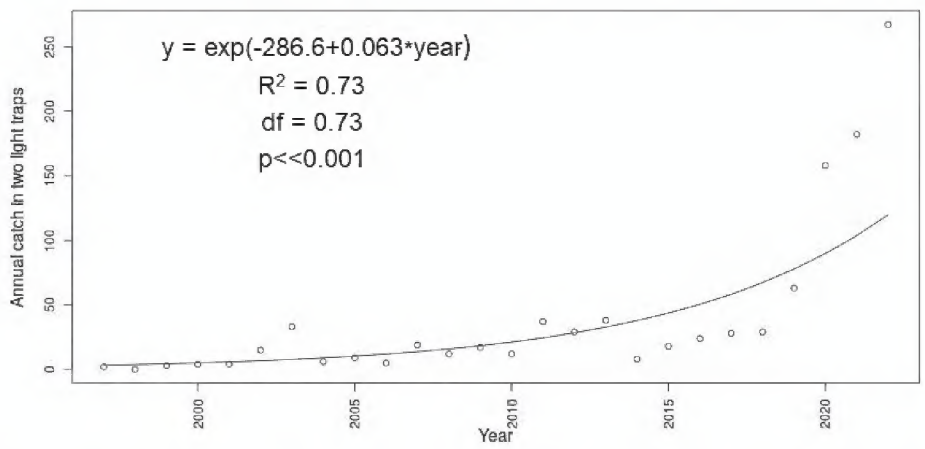

Figure 2. Specimens of *Potamophylax cingulatus* caught in two light traps in south Iceland 1997–2022.

surveys, it is estimated that the species has dispersed 7–9 km/year (Fig. 1).

Two traps were set up at Tumastadir in Fljótshlid, south Iceland in 1995 to monitor Lepidoptera and Trichoptera. The first record of *P. cingulatus* was caught in 1997. The annual catch of *P. cingulatus* in light traps grew exponentially from 1997, with now about 267 specimens caught in 2022 (Fig. 2).

Micropterna sequax was recorded for the first time in 2008 at Mógilsá near Reykjavik, three years after the beginning of the operation of the light trap (Fig. 3). Only two specimens were recorded during the first year. The growth rate of the catch, an indication of population size, was continuous from 2008 to 2022, two specimens in the beginning and 63 in 2022 with the greatest catch of 144 in 2021 (Fig. 4). The second site where *M. sequax* was found in a light trap was at Hvanneyri in 2018 with the total of eight specimens from 2018 to 2022. The direct distance is 40 km, estimating a dispersal rate of 4 km/year. In 2021, it was also found at Kjós, Hvalfjodur (64°18'16"N, 21°46'41"W) (one specimen identified from a photograph), between Mógilsá and Hvanneyri.

Discussion

Iceland is still in the process of post-glacial colonisation by insects. By 1931, ten species of Trichoptera were known from Iceland. It is unlikely that large species of Trichoptera, like *P. cingulatus* or *M. sequax* could have escaped the notice of entomologists, who sampled small caddisfly species as *A. zonella*, which had been replaced by *P. cingulatus* in the streams in the north-east and east in 1974–1978 by predation (Gíslason 1981b). Analysis of geographic variation in the COI mtDNA barcode marker in Trichoptera species from Iceland indicates distinct histories where different species show indication of varying times since colonisation of the island and separate evolution restricted to Iceland (Gíslason and Pálsson 2020; unpublished data). Originating from the Palaearctic, *P. cingulatus* showed no variation in the Icelandic population (Gíslason et al. 2015). Its possible migration route could be traced by COI mtDNA sequence from central Europe during the Ice Age, towards western France and north to Britain and onwards to the Faroe Islands and Iceland, a colonisation that presumably took place in

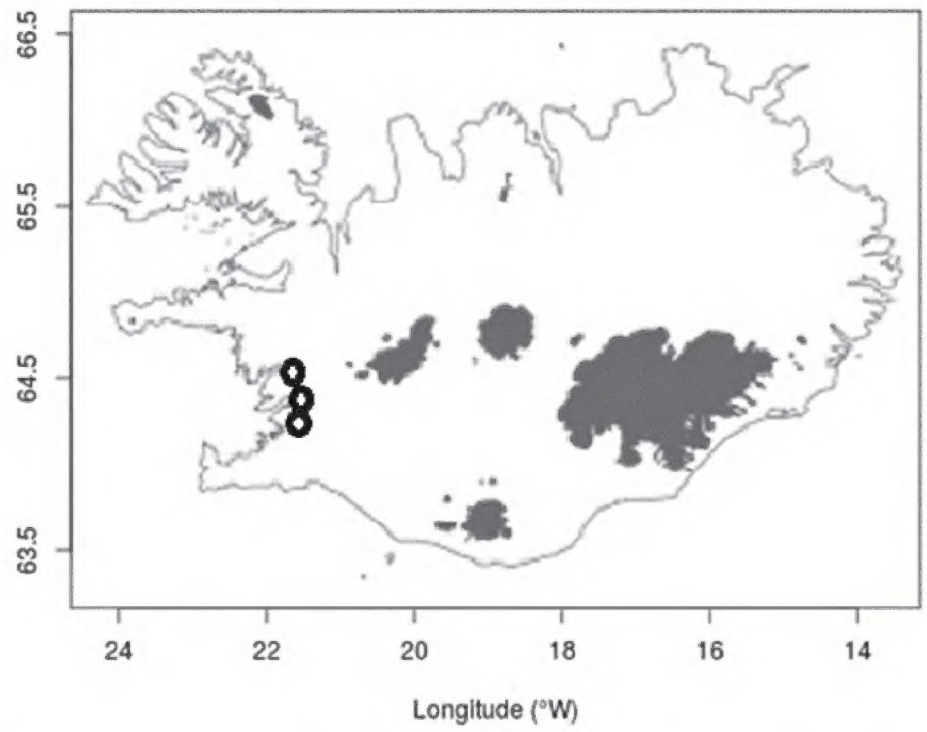

Figure 3. Records of *Micropterna sequax* 2008–2022 are shown by bold circles. Glaciers shown in dark grey. Dispersal 2008 to 2018 is 40 km/10 years = 4 km/year.

the mid-20th century. *Micropterna sequax* was misidentified as *M. lateralis* in 2010 when it was first recorded (Ólafsson and Gíslason 2010). The identification was based on the keys and illustrations by Macan (1973) and McLachlan (1874–1890). A specimen of the *Micropterna* species in Iceland was sent to BOLD (ICEFI001-17.COI-5P). It turned out to be 92% related to *M. lateralis* and 98.7–99.9% related to *M. sequax* populations in northern Europe (Snaebjörn Pálsson, pers. com). This led to revision of the identification and all specimens of *Micropterna* in the Icelandic Institute of Natural History with the aid of the illustrated key by Tobias and Tobias (2023). *Micropterna sequax* did not show any variation in COI mDNA, indicating a recent colonisation. The dispersal rate of *P. cingulatus* within Iceland was 7–9 km/year over a period of 30 years, dispersed all over the lowlands of Iceland, an area twice larger than its distribution in 1974–1978. *Micropterna sequax* is such a recent coloniser that its dispersal has only been 40 km since its first record in 2008, a dispersal rate of 4 km/year.

When a recent species has established itself in an area, its population grows at an exponential rate in the area and when it has established itself, it disperses fast. It will be interesting to follow the population growth of these species until they have reached their population size limit. Other Trichoptera species in the traps have kept a relatively constant catch over the years.

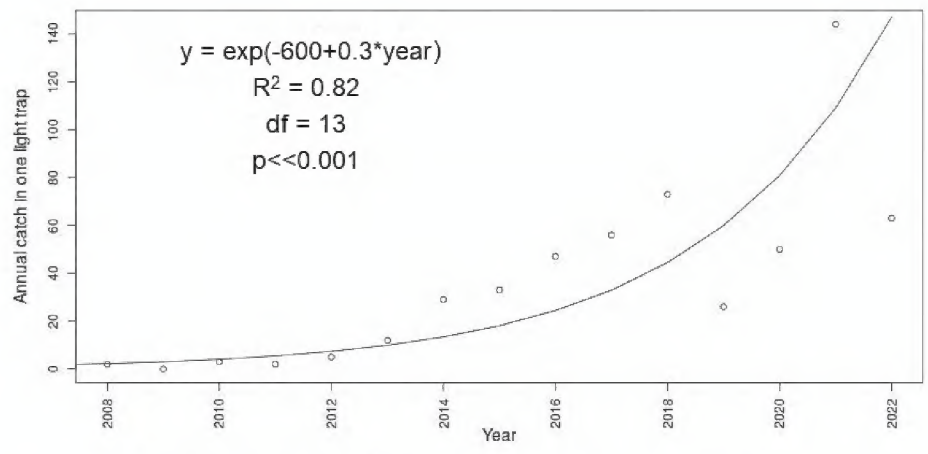

Figure 4. Specimens of *Micropterna sequax* caught in a light trap at Mógilsá near Reykjavik 2008–2022.

The close similarity of the mtDNA sequences within these two species and no distinct lineage from European population suggest that the post-glacial colonisation is still ongoing, which is supported by the observed and tracked colonisation of two out of 12 species in Iceland during the last 70 years.

Conclusions

It is possible to conclude from this that, when species establish a population on a large island like Iceland, the population builds up exponentially and, when it has established itself, it disperses fast. For *P. cingulatus*, the dispersal rate was about 7–9 km/year, but the dispersal rate for the more recent settler *M. sequax* is 4 km/year. The colonisation of these two species shows presumably that post-glacial colonisation by insects is still in progress in Iceland.

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